



Figure IV-3-36. Example of a reflective sand beach: Newport Beach, California, April 1993

$$\varepsilon = \frac{a_b \omega^2}{g \tan^2 \beta} \quad (\text{IV-3-4})$$

where

$a_b$  = breaker amplitude

$\omega$  = incident wave radian energy ( $2\pi/T$  where  $T$  = period)

$g$  = acceleration of gravity

$\beta$  = the gradient of the beach and surf zone

Strong reflection occurs when  $\varepsilon \leq 2.0$ -2.5; this situation defines the highly reflective extreme. When  $\varepsilon > 2.5$ , waves begin to plunge, dissipating energy. Finally, when  $\varepsilon > 20$ , spilling breakers occur, the surf zone widens, and turbulent dissipation of wave energy increases with increasing  $\varepsilon$ .

(5) Intermediate beach stages. These exhibit the most complex morphologies and process signatures.

(a) Longshore bar-trough state (Figure IV-3-34b). This beach form can develop from an antecedent dissipative profile during an accretionary period. Bar-trough relief is higher and the shoreface is much steeper than on the dissipative profile. Initial wave breaking occurs over the bar. However, in contrast to



**Figure IV-3-37. Example of a reflective cobble beach: Aldeburgh, Suffolk (facing the North Sea), August 1983. Note the steep berm and the lack of sand-sized sediment. In the background is part of the town of Aldeburgh, which has lost many buildings and churches since the Middle Ages due to erosion**

the dissipative beach, the broken waves do not continue to decay after passing over the steep inner face of the bar, but re-form in the deep trough. Low-steepness waves surge up the foreshore; steeper waves collapse or plunge at the base of the foreshore, followed by a violent surge up the subaerial beach (Wright and Short 1984). Runup is relatively high and cusps often occur in the swash zone.

(b) Rhythmic bar and beach (Figure IV-3-34c). Characteristics are similar to the longshore bar-trough state (described above). The distinguishing features of the rhythmic bar and beach state are the regular longshore undulations of the crescentic bar and of the subaerial beach (Figures III-2-23 (ocean) and IV-3-38 (lake)). A weak rip current circulation is often present, with the rips flowing across the narrow portions of the bar. Wright and Short (1984) state that incident waves dominate circulation throughout the surf zone, but subharmonic and infragravity oscillations become important in some regions.

(c) Transverse-bar and rip state (Figure IV-3-34d). This morphology commonly develops in accretionary sequences when the horns of crescentic bars weld to the beach. This results in dissipative transverse bars (sometimes called “mega-cusps”) that alternate with reflective, deeper embayments. The dominant dynamic process of this beach state is extremely strong rip circulation, with the seaward-flowing rip currents concentrated in the embayments.

(d) Ridge and runnel/low tide terrace state (Figures IV-3-34e, IV-2-31 (ocean), and IV-3-39 (lake)). This beach state is characterized by a flat accumulation of sand at or just below the low tide level, backed by a steeper foreshore. The beach is typically dissipative at low tide and reflective at high tide.



**Figure IV-3-38. Gravel cusps at St. Joseph, Michigan, November 1993. This is an example of a rhythmic bar and beach on a freshwater coast without tides but subject to irregular seicheing**

*e. Processes responsible for shoreface sediment movement.*

(1) Despite intense study for over a century, the subject of sand movement on the shoreface is still poorly understood. Sand is moved by a combination of processes including the following (Pilkey 1993, Wright et al. 1991):

- (a) Wave orbital interactions with bottom sediments and with wave-induced longshore currents.
- (b) Wind-induced longshore currents.
- (c) Turbidity currents.
- (d) Rip currents.
- (e) Tidal currents.
- (f) Storm surge ebb currents.
- (g) Gravity-driven currents.
- (h) Wind-induced upwelling and downwelling.
- (i) Wave-induced upwelling and downwelling.